

Institute of Polar Studies

Report No. 31

Photomicrographs of Some Sedimentary and Volcaniclastic Permian and Triassic Beacon Rocks from the Beardmore Glacier Area, Antarctica

by

Peter J. Barrett

Institute of Polar Studies

May 1969



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PHOTOMICROGRAPHS OF SOME SEDIMENTARY AND VOLCANICLASTIC
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PETER J. BARRETT
Institute of Polar Studies
The Ohio State University
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"Photomicrographs of some sedimentary and volcaniclastic Permian and Triassic Beacon rocks from the Beardmore Glacier area, Antarctica"

- p. 1, line 9 Delete parentheses around quartz arenite.
- p. 2 and p. 3 The diagrams for figures 1 and 2 should be reversed.

Acknowledgments

I would like to thank Dr. Charles H. Shultz, Department of Geology, The Ohio State University, for the use of his equipment, and his help and advice in taking the photomicrographs. Dr. David H. Elliot, John D. Gunner, and John F. Splettstoesser reviewed the manuscript. Financial support was provided by National Science Foundation Grant GA-1159 awarded to The Ohio State University Research Foundation.

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Introduction

The volcanic character of the Permian and Triassic Beacon rocks of the central Transantarctic Mountains has only recently been recognized (Barrett, in McGregor, 1965; Minshew, 1967; Barrett and others, 1967, 1968), but no photomicrographs illustrating volcanic components of the sedimentary rocks or textures of the volcanoclastic rocks have been published. This set of photographs has been prepared mainly to document some of the volcanic features of what until recently was considered a purely clastic sedimentary sequence. Photomicrographs of arkose and (quartz arenite), and of partly altered plagioclase, which is characteristic of the volcanic sandstone, have been included for comparison.

Although most features in the photographs are volcanic in origin, many of the samples are of sandstone. The sandstone classification used here (Fig. 1) is based on the mineralogy of the sand fraction and follows the scheme of Folk (1968). However, the subarkose-sublitharenite boundary has been extended to include as much as 30 percent of the non-quartz sandstone, in order to minimize the division of natural compositional groups. The term "volcanic arenite" is used in preference to litharenite where most of the lithic material is of volcanic origin. The term "volcanic sandstone" is used informally for sandstones in which volcanic detritus constitutes at least ten percent of the rock. Thus, volcanic sandstone includes all but the most quartzose volcanic arkose, feldspathic volcanic arenite and volcanic arenite.

The precise locations and stratigraphic positions of samples illustrated here are given in Barrett (1968, Fig. 3 and Appendix I). The first two characters of the sample label designate the stratigraphic section; the last two are the sample number. For example, F249 refers to sample 49 in stratigraphic section F2. Figure 2 shows the location of all stratigraphic sections measured.

The more important rock types found in the postglacial Permian and Triassic Beacon strata (see Table) are briefly described and discussed below to help place the photographic material in its proper perspective.

Arkose and Subarkose

Sandstones from the Fairchild Formation, and part of the Buckley Formation, form a single group that, on a QFR diagram (Fig. 1), covers the subarkose field and the quartzose part of the arkose field. The quartz normally is subangular to subrounded, simple, and more or less unstrained; overgrowths and sutured contacts are common. Most of the feldspar is sodic plagioclase (albite and oligoclase-andesine) that ranges in degree of alteration from slightly cloudy to heavily citized. In the Fairchild Formation and in the Buckley Formation west of 165°E, K-feldspar (fresh orthoclase and microcline) forms about

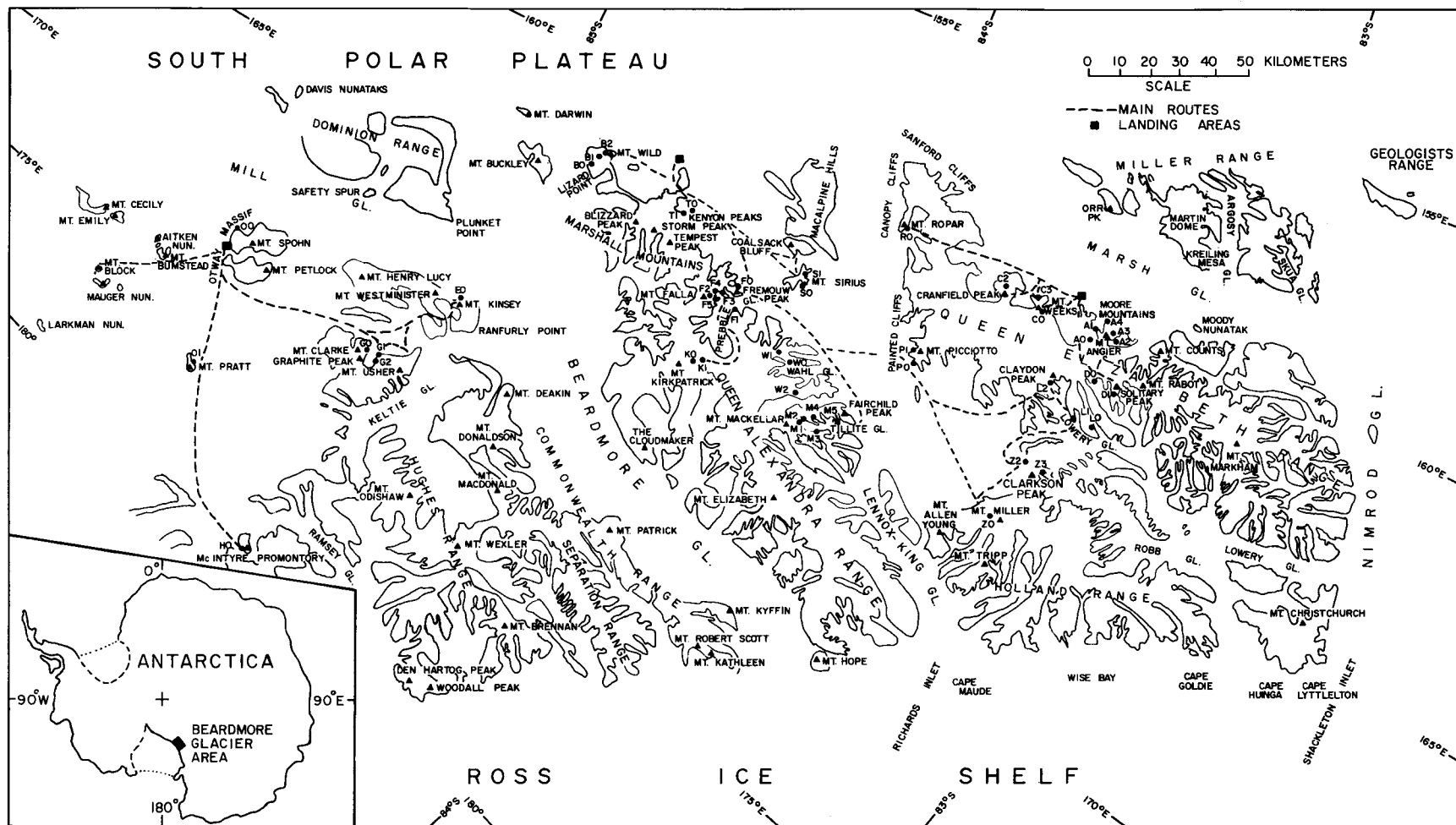


Figure 1. Mean values for groups of sandstone samples from the post-glacial Permian and Triassic rocks of the Beardmore Glacier area. The dotted lines enclose fields defined by σ (one standard deviation) calculated for each of the three components used for the plot. The number of samples in each group ranges from 18 to 36. Classification after Folk (1968).

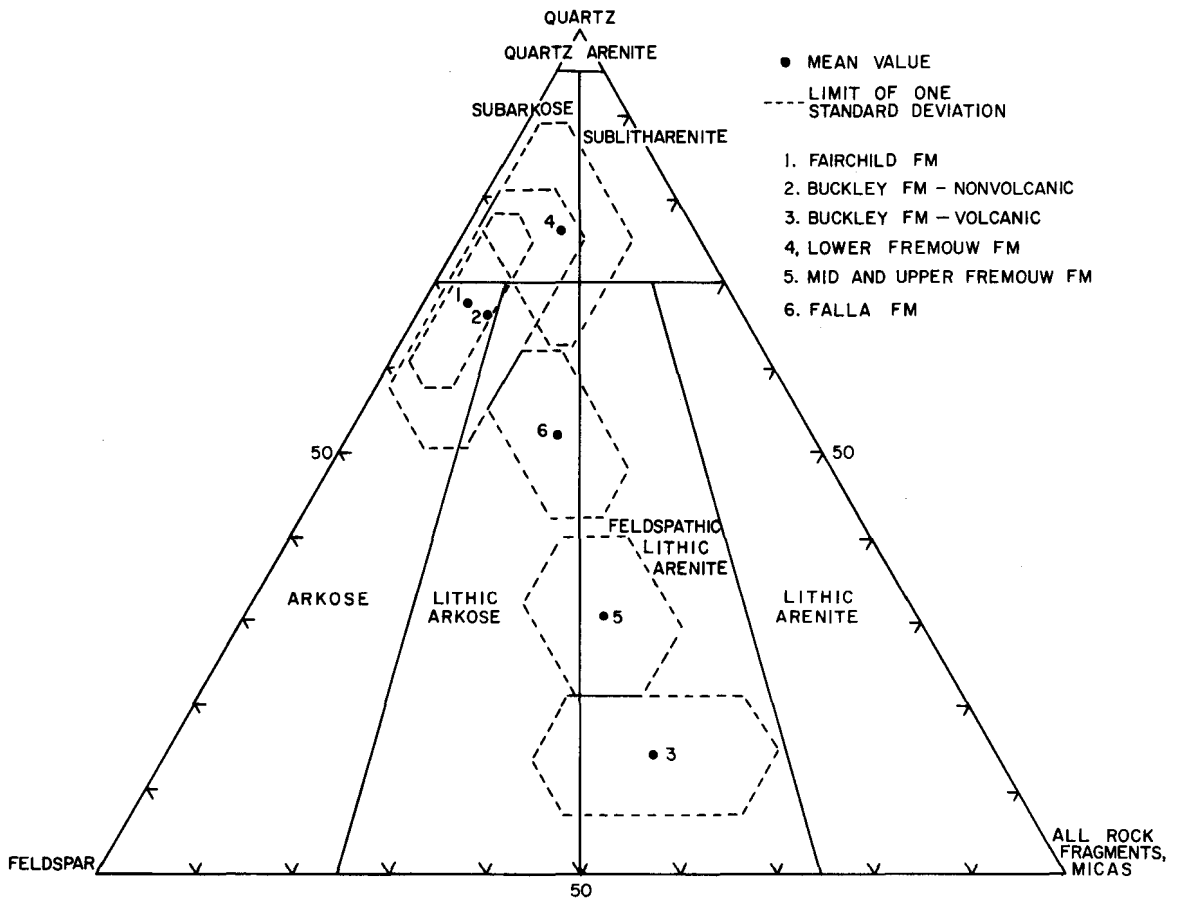


Figure 2. The Beardmore Glacier area, central Transantarctic Mountains. Stratigraphic sections are indicated by two-character labels, e.g. B2.

Post-Ordovician stratigraphy of the Beardmore Glacier area.

Age	Formation	Description	Thickness (m)	
JURASSIC	Ferrar Group	Kirkpatrick Basalt	Tholeiitic flows, rare shale lenses with conchostracans, ostracods.	600+
		Ferrar Dolerite	Numerous sills and a few dikes.	about 1000
		Prebble Fm.	Volcanic mudflows, agglomerate, tuff and tuffaceous sandstone.	0-460+
TRIASSIC		Falla Fm.	Volcanic sandstone, shale, <u>Dicroidium</u> ; tuff dominates upper part.	160-530
		Fremouw Fm.	Subarkose, volcanic sandstone, greenish-gray mudstone; logs, coal, <u>Dicroidium</u> near top.	about 650
		DISCONFORMITY		
PERMIAN	Beacon Sequence	Buckley Fm.	Arkosic and volcanic sandstone, dark gray shale, coal, <u>Glossopteris</u> .	about 750
		Fairchild Fm.	Massive subarkose and arkose.	120-220
		Mackellar Fm.	Dark shale and fine-grained sandstone.	60-140
		Pagoda Fm.	Tillite, sandstone and shale.	100-400
		DISCONFORMITY		
DEVONIAN?		Alexandra Fm.	Quartz arenite, sandstone.	0-400
		ANGULAR UNCONFORMITY		
ORDOVICIAN - PRECAMBRIAN		Basement metasedimentary complex intruded by granitic rocks.		

one-third of the total feldspar, but in the Buckley Formation east of 165°E K-feldspar is normally absent. The matrix commonly is sericite, which locally replaces plagioclase; a few samples are calcite-cemented. Biotite, muscovite and garnet, probably almandine-pyrope (Barrett, 1966), are common accessory minerals.

Subarkose is also found in the lower part of the Fremouw Formation, but here it is part of a group of quartz-rich sandstones that characterize the lowest part of the Triassic section in the Beardmore Glacier area. The mineralogy of the non-quartz fraction is very variable; K-feldspar ranges from 0 to 13 percent, plagioclase ranges from 0 to 21 percent, and they tend to be mutually exclusive. The texture is similar to the Fairchild and Buckley sandstone, though quartz overgrowths are much more evident in the more quartz-rich samples.

Volcanic Sandstones

The lowest volcanic sandstone in the Beacon sequence occurs from 100 to 300 m above the base of the Buckley Formation in the Beardmore Glacier area, and has been found in a similar stratigraphic position in the Scott Glacier area about 500 km to the southeast (Minsheu, 1967). In the Buckley Formation volcanic sandstone interfingers with sandstone of the arkose-subarkose group, although volcanic sandstone dominates near the top of the formation. Quartz in the Buckley volcanic sandstone is mainly angular-subangular, simple and unstrained, and the feldspar is subhedral sodic plagioclase. The plagioclase normally is cloudy or sericitized; about half is untwinned and zoning is extremely rare. The most common volcanic fragments are very fine grained with low first-order birefringence and, in some instances, an indistinct foliation. They are thought to have once been largely volcanic glass or pumice. Other fragments consist of feldspar microlites, oriented randomly in some grains and subparallel in others. Some fragments are holocrystalline; others have a dark-brown semi-opaque mesostasis. Iron ores are common as accessory minerals, and a little muscovite and biotite was found. Volcanic sandstones of the Fremouw and Falla Formations have similar volcanic fragments but have a larger quartz and K-feldspar content, indicating dilution of the volcanic with some non-volcanic detritus of probable subarkosic composition.

Plagioclase, volcanic fragments and matrix in the volcanic sediments of the Permian and Triassic Beacon sequence commonly are replaced by zeolite or calcite. The zeolite is laumontite in volcanic sandstone in the Buckley and Fremouw Formations, whereas in the sandstone, tuff and volcanic conglomerate of the Falla and Prebble Formations it is clinoptilolite, analcite or mordenite (identifications by X-ray diffractometer).

Prehnite-bearing Rocks

Prehnite has been found in Beacon rocks of the Beardmore Glacier area in four situations that differ by reason of their stratigraphic position and lithology. The strata in all four cases reached temperatures of at least 300°C as a result of diabase intrusion, and they lie from 1600 to 2500 m stratigraphically below the top of the youngest Mesozoic rocks in the Beardmore Glacier area. There seem to be no other common factors. The occurrences are described in ascending stratigraphic order; the identification of prehnite in G015C was confirmed by X-ray diffractometer.

- (a) Prehnite was recognized by the writer in a geode and in thin sections of siltstone collected by Dr. J. F. Lindsay from the Mackellar Formation in the Tillite Glacier area.
- (b) Prehnite is the major constituent of calc-silicate hornfelses near diabase sills in the lower part of the Buckley Formation. Here it is associated with calcite and metamorphic grossularite (L203, Z026).
- (c) Prehnite replaces plagioclase and has grown in the matrix of a silicified volcanic sandstone from the upper part of the Buckley Formation (W108).
- (d) Prehnite is the cement in a quartzose sandstone at the base of the Fremouw Formation (E004, G015C). Sample G015C was taken from the same locality and stratigraphic horizon as a sample collected by McGregor in which anhydrite was identified by Barrett and McGregor (McGregor, 1965). Anhydrite has optical properties similar to prehnite.

Tuff

Fine-grained vitric tuff dominates the upper part of the Falla Formation and is locally interbedded with volcanic conglomerate of the Prebble Formation. A single tuff bed 2 m thick is known from the Fremouw Formation; it could be positively identified only because the glass shards had been replaced by calcite. Other "siltstones" in the Fremouw Formation also may once have been tuffs. In the Falla Formation the shards are best seen where they are picked out by pink iron staining. The texture of the tuffs gives no indication of welding or collapse structures that would indicate hot deposition. Most tuff samples include small scattered angular quartz and feldspar fragments. The feldspar is mainly high-temperature oligoclase, but some anorthoclase was found. Four chemical analyses (Barrett, in preparation) indicate that the tuffs are of rhyolitic composition. The degree of secondary alteration is difficult to determine, but some tuffs have

been altered to the extent that they contain sufficient clinoptilolite, analcite or mordenite for positive mineral identification by X-ray diffractometer.

Black spheroidal structures as much as 1 cm across are common in the uppermost tuff beds of the Falla Formation and are scattered through some tuffs in the Prebble Formation. They have been identified as accretionary lapilli, balls of fine volcanic ash that formed in water-charged volcanic ash clouds (Moore and Peck, 1962) in a manner similar to hailstones.

Paraconglomerate

Paraconglomerate, a poorly-sorted, open-framework conglomerate, defines the base and typifies the Prebble Formation in the Beardmore Glacier area. It contains large amounts of acidic volcanic debris, and locally boulders, as much as 1 m across of diabase, basalt, sandstone, siltstone, and rare coal are embedded in it. The paraconglomerate is believed to have been deposited by volcanic mudflows.

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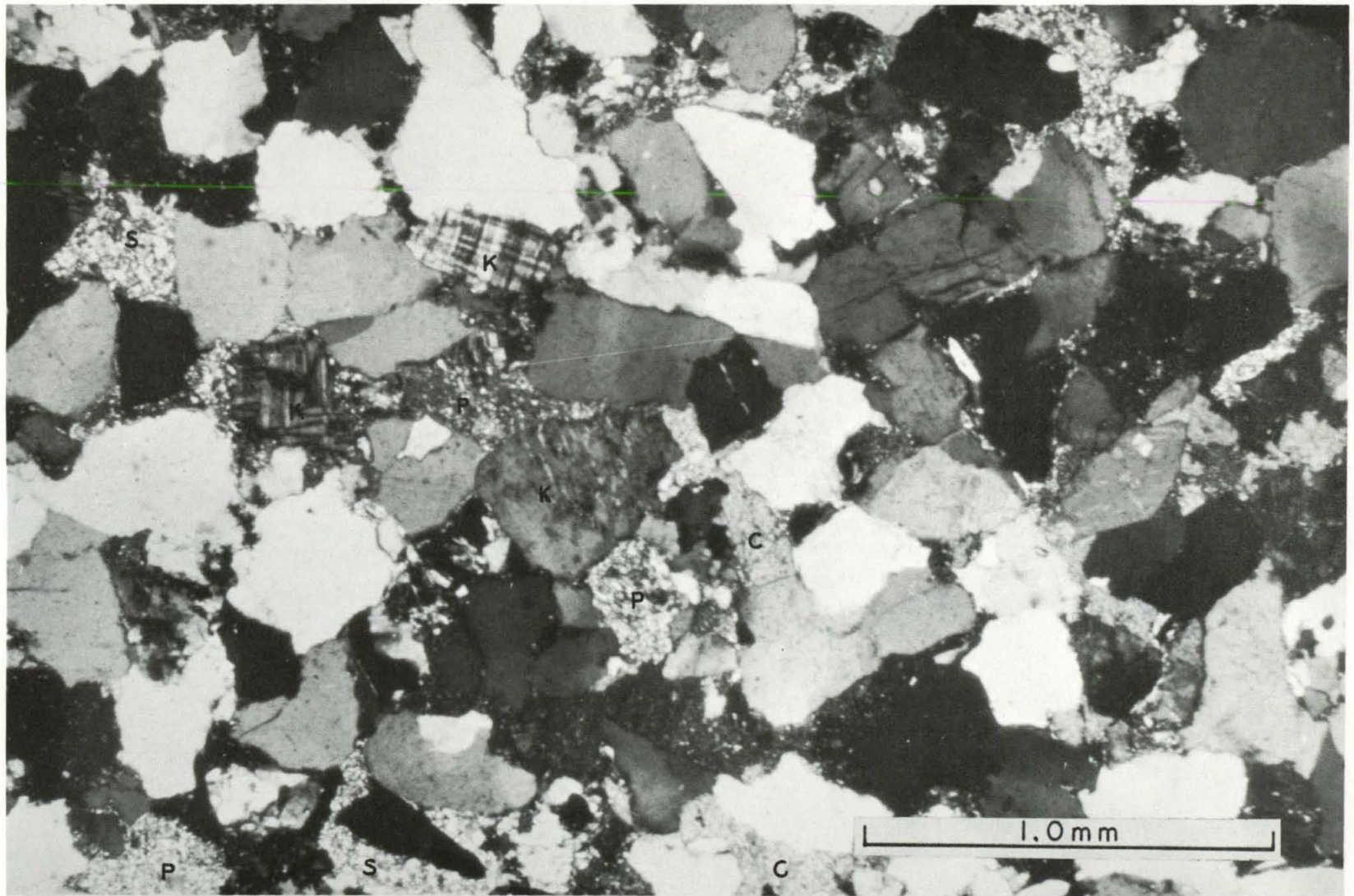


Figure 3. Arkose (L013), Fairchild Formation. Plagioclase is somewhat sericitized, but the microcline (upper left) is fresh. K-feldspar - K, plagioclase - P, sericite - S, calcite - C. Crossed nicols.

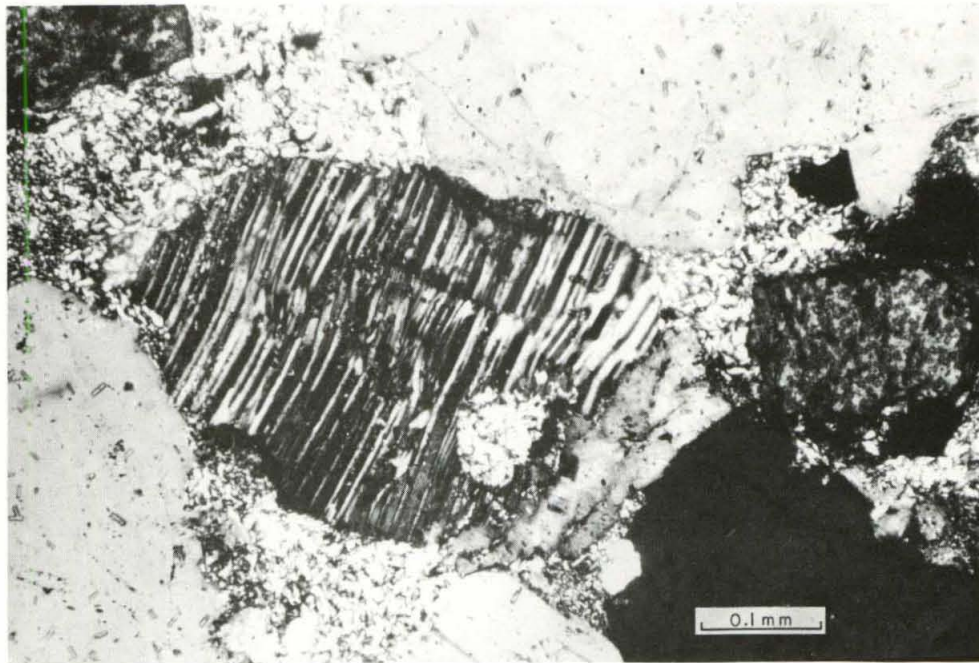
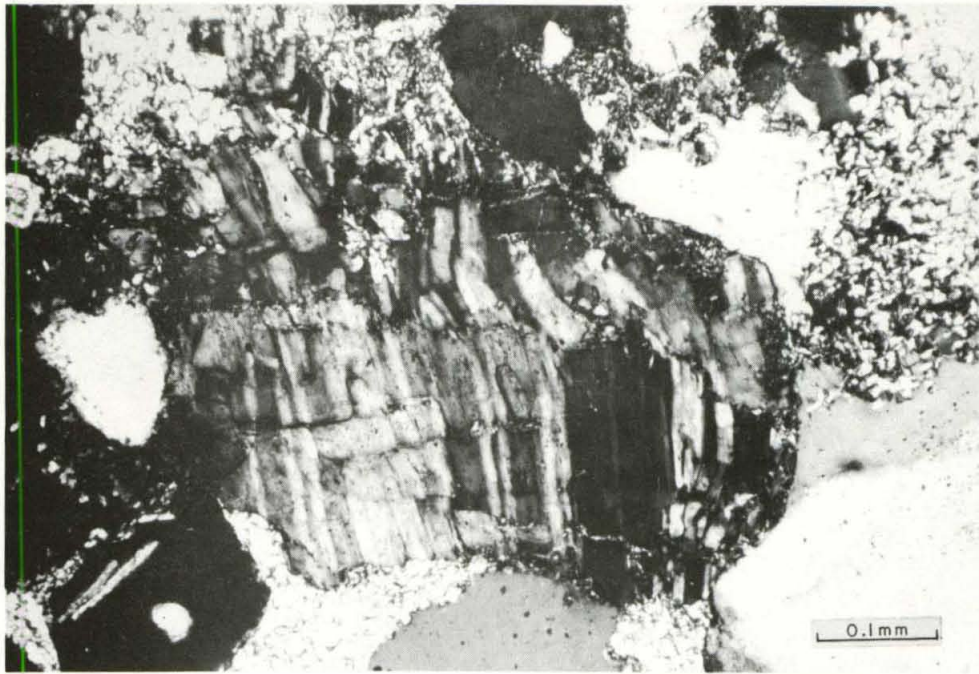


Figure 4. Arkose, L112 above, L114 below, Buckley Formation. Twin lamellae in the plagioclase have been bent and sheared by stress, probably as a result of diabase intrusion. The adjacent grains are quartz, and the matrix is sericitic. Crossed nicols.

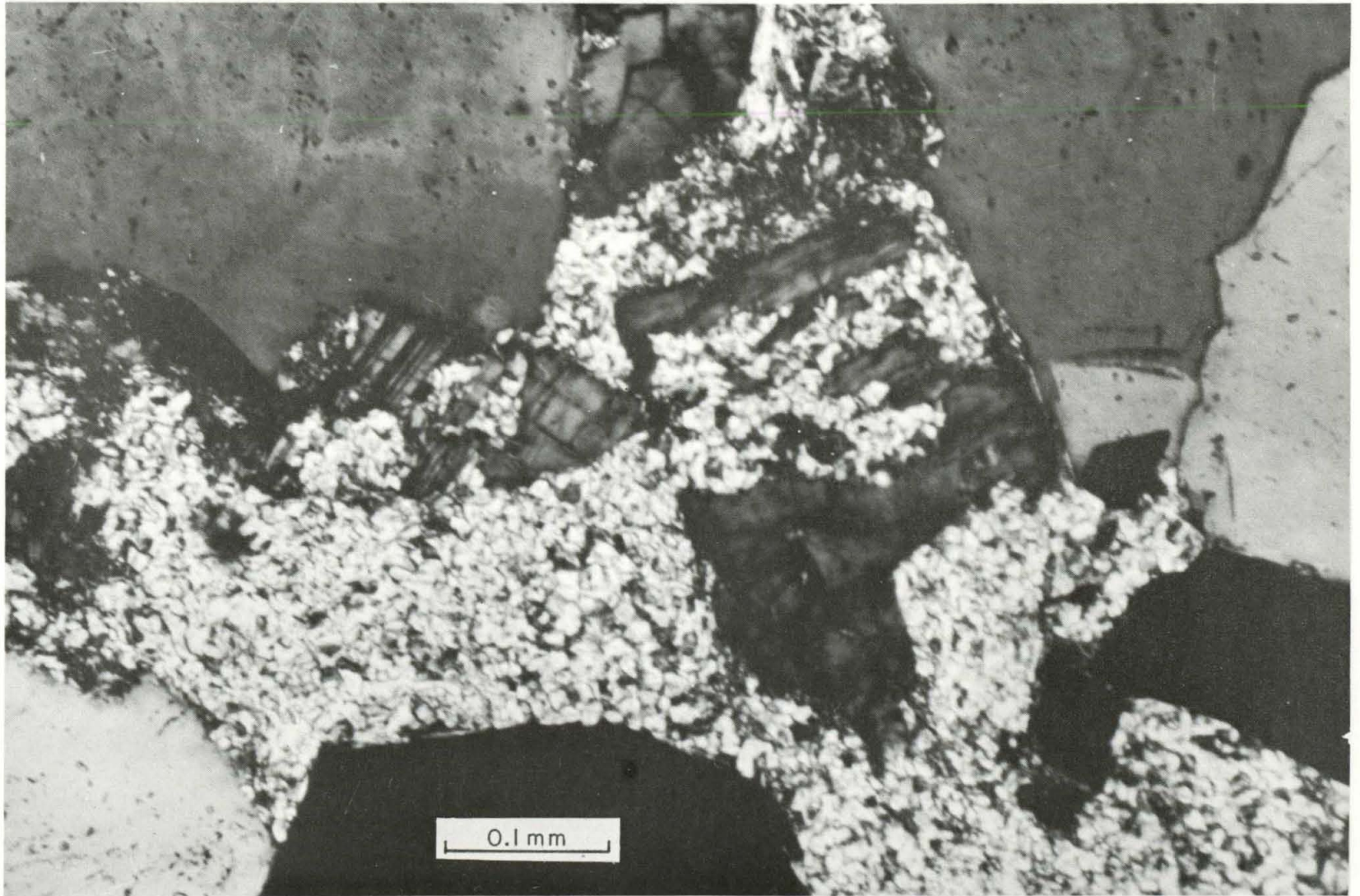


Figure 5. Arkose (L112), Buckley Formation. The two plagioclase grains (center) have been replaced extensively by sericite. Crossed nicols.

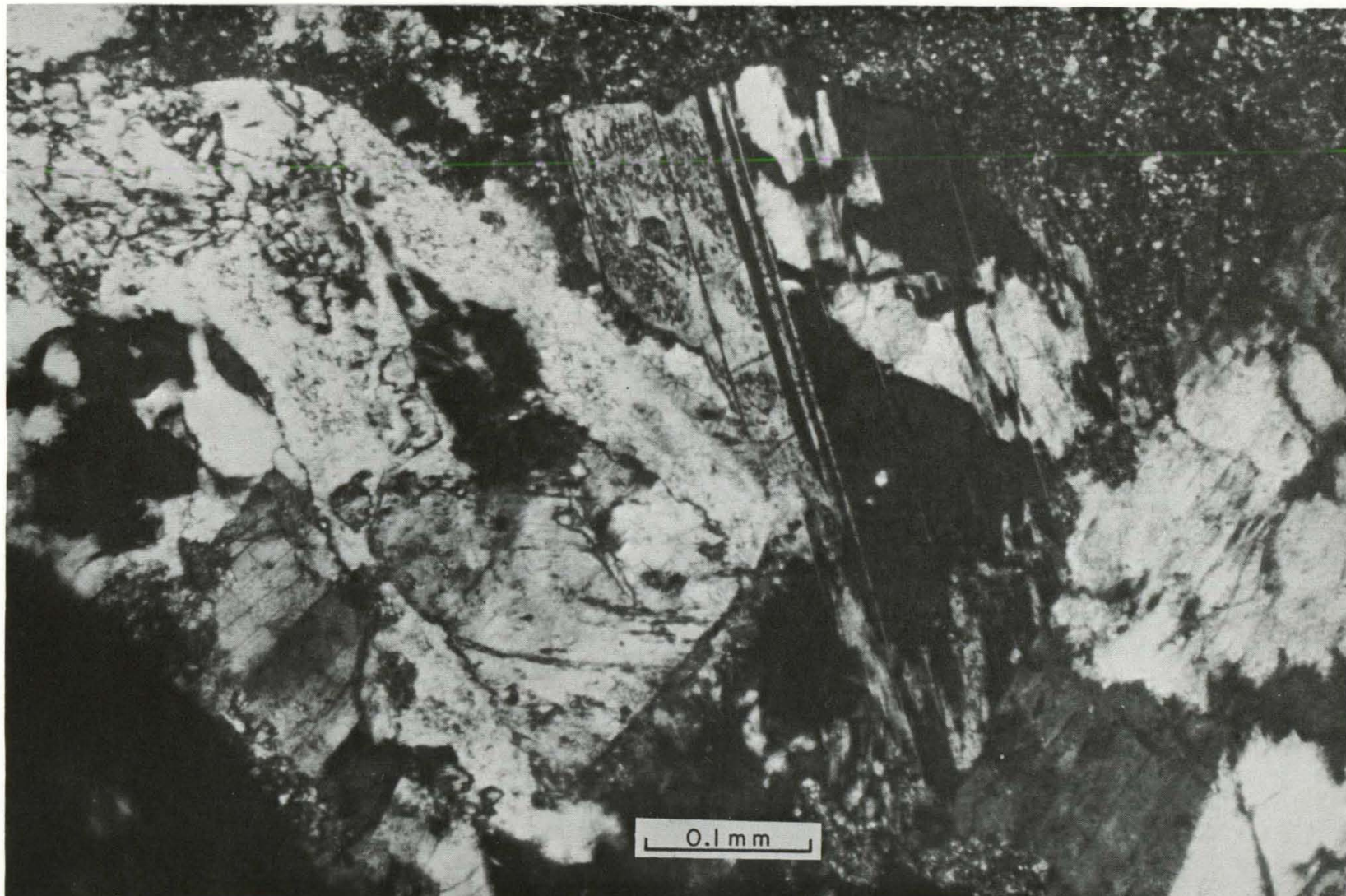


Figure 6. Feldspathic volcanic arenite (B200), Buckley Formation. Laumontite (white) has partly replaced plagioclase (gray). Crossed nicols.

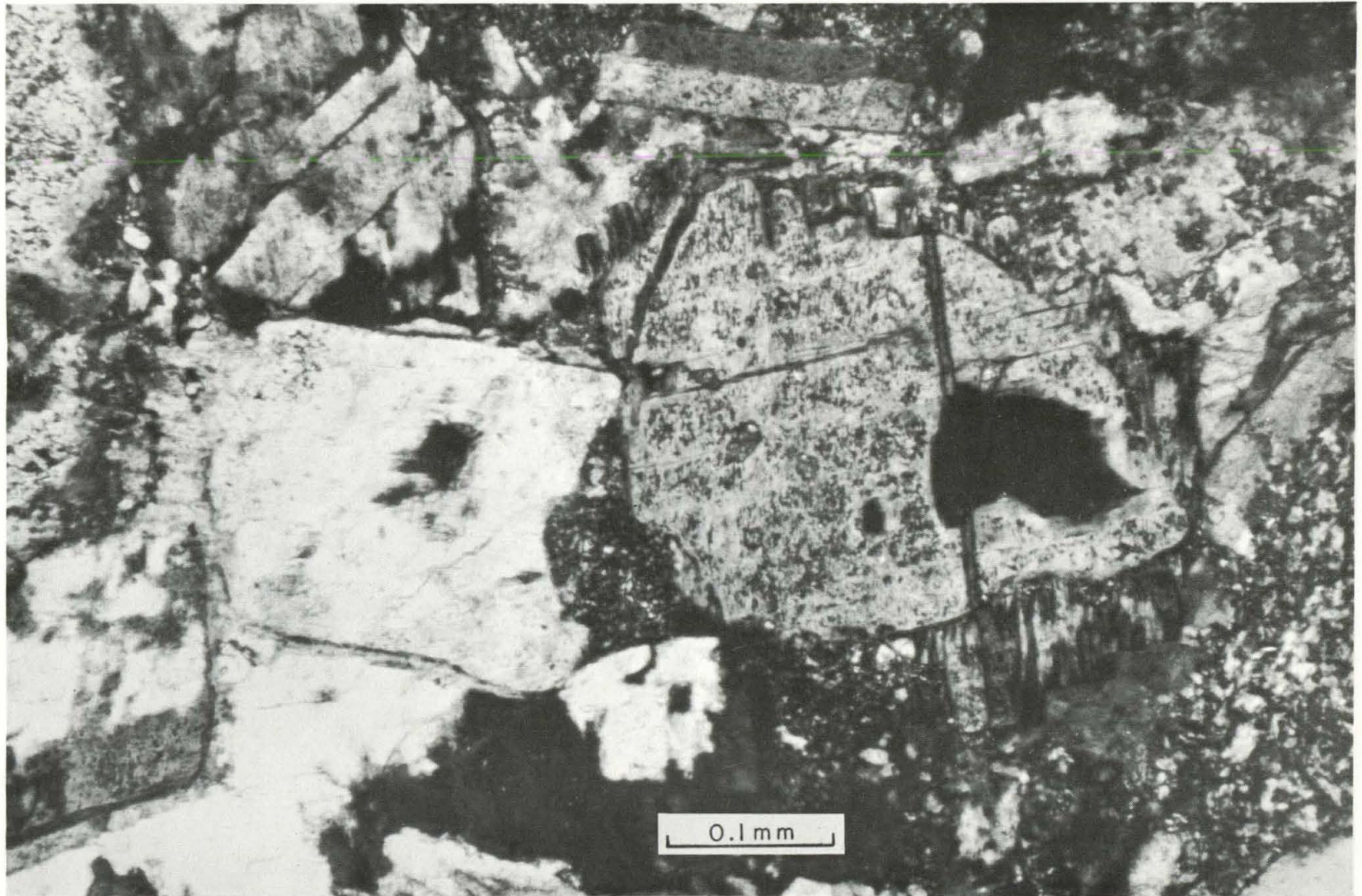


Figure 7. Feldspathic volcanic arenite (B200), Buckley Formation. Laumontite has completely replaced the grain to the left; the twinned plagioclase grain to the right has not been zeolitized, and is surrounded by a thin rim of secondary twinned plagioclase. Crossed nicols.

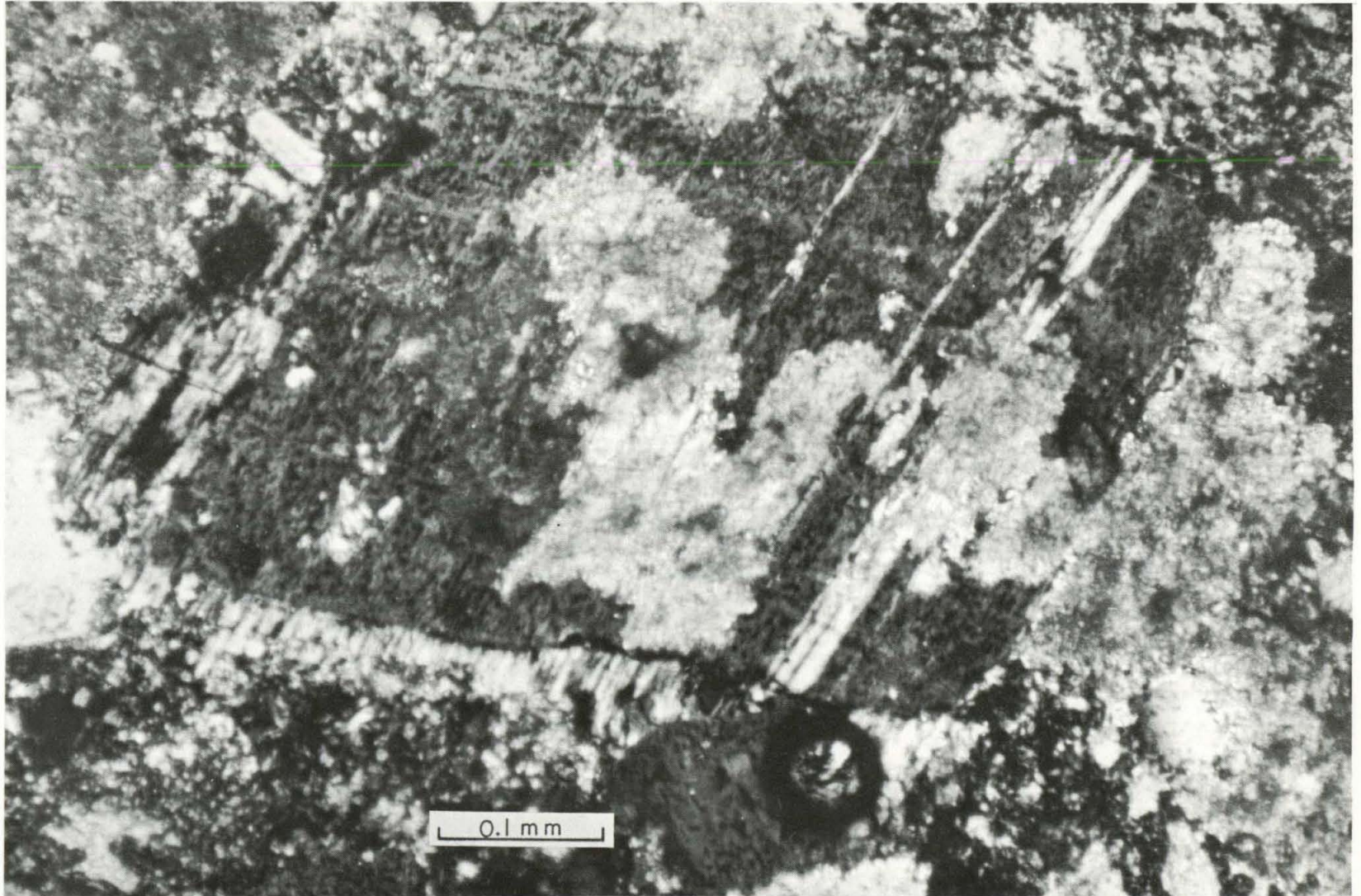


Figure 8. Volcanic arkose (Holl), Buckley Formation. Calcite (white, center) is replacing plagioclase. The grain is surrounded by a thin rim of finely-twinning secondary plagioclase. Crossed nicols.

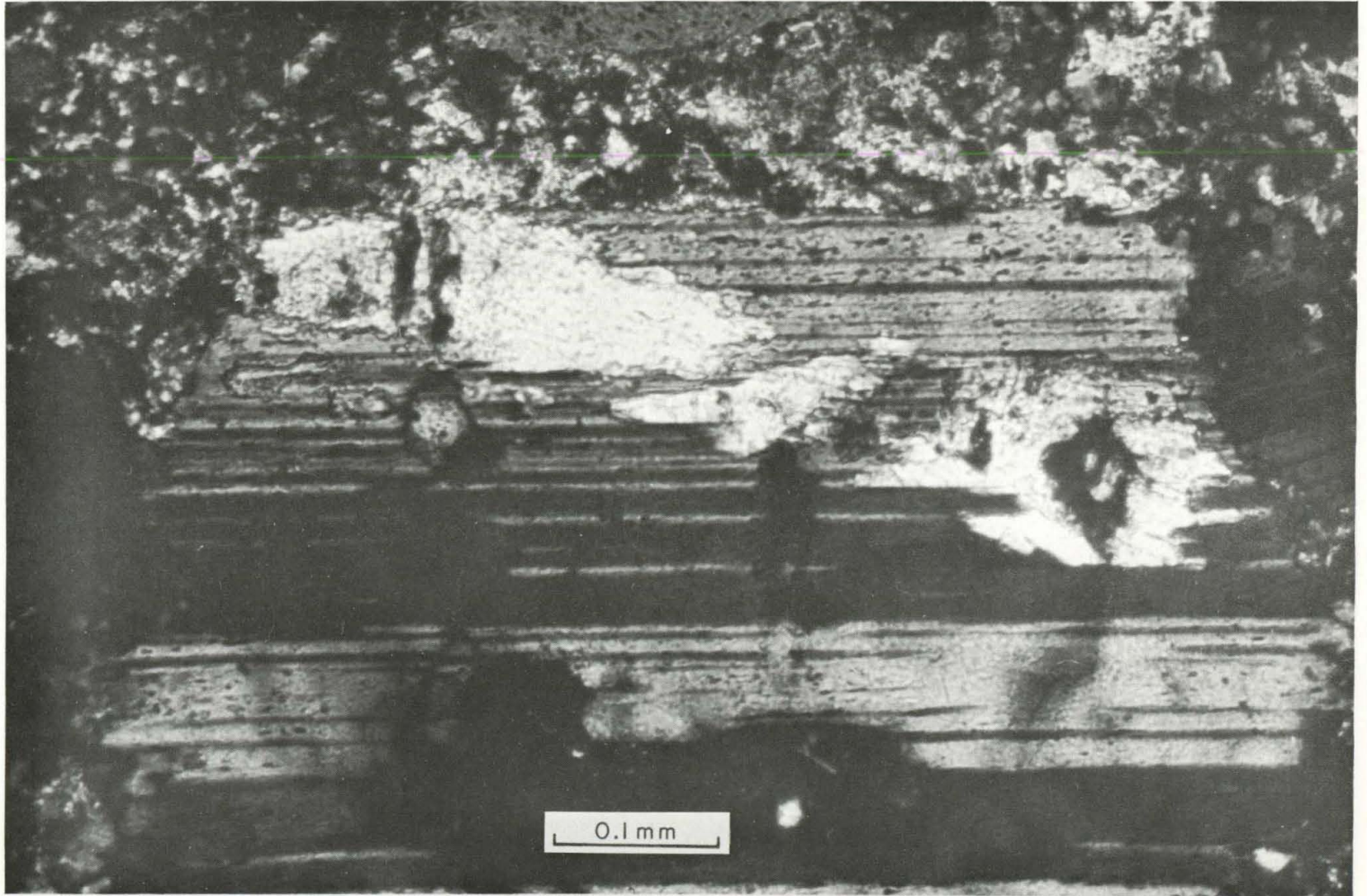


Figure 9. Silicified volcanic arkose (W108), Buckley Formation. Prehnite (white) has partly replaced the plagioclase. Crossed nicols.

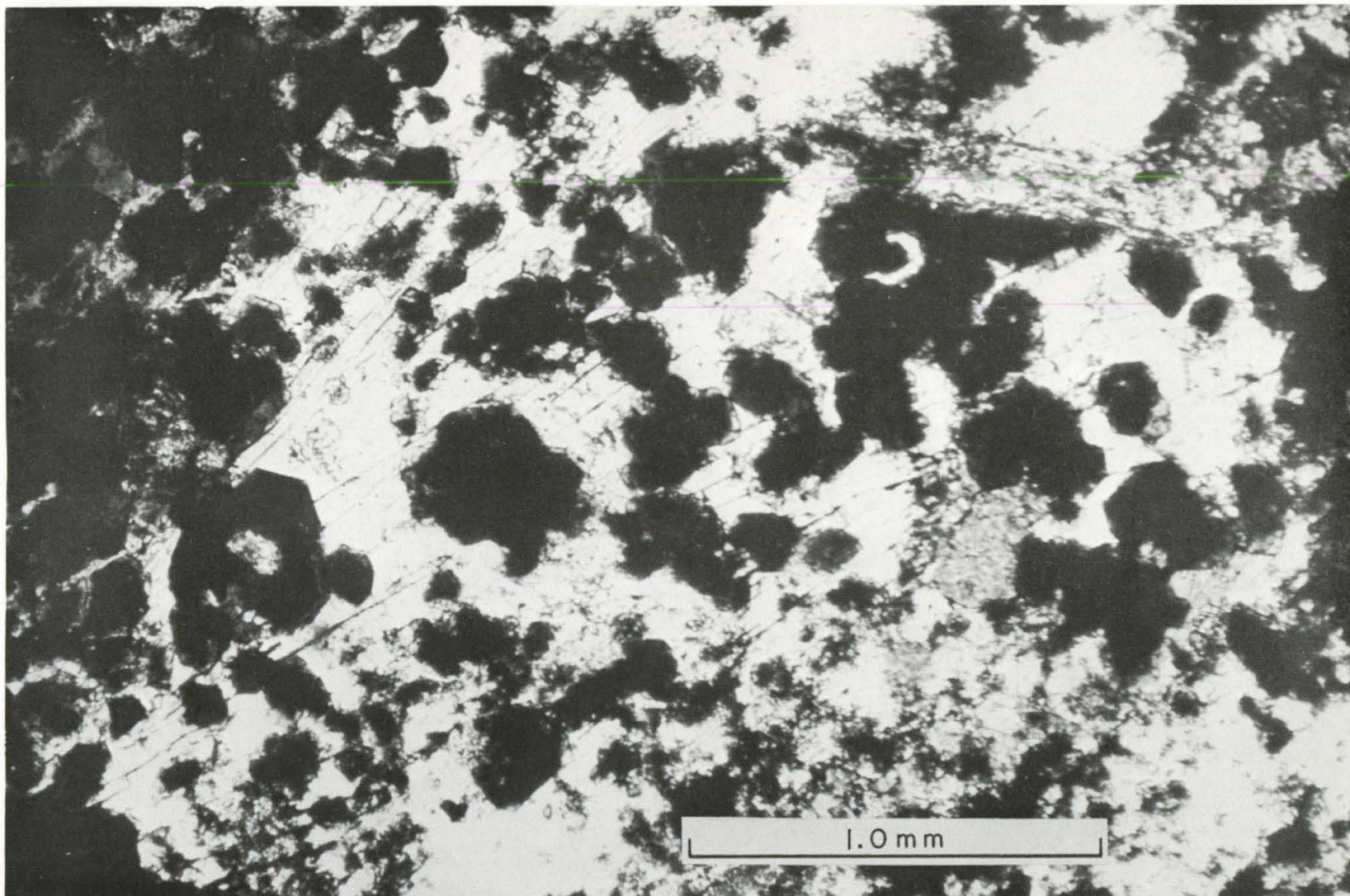


Figure 10. Calc-silicate hornfels (Z026), Buckley Formation. The sample was taken from a "sandstone" bed 5 m above a 260-m-thick diabase sill and 50 m below a 200-m-thick sill. About 60% of the rock is well-crystallized prehnite; grossularite appears as scattered euhedral isotropic grains. Calcite forms about 20% of the thin section but is not seen here. Crossed nicols.

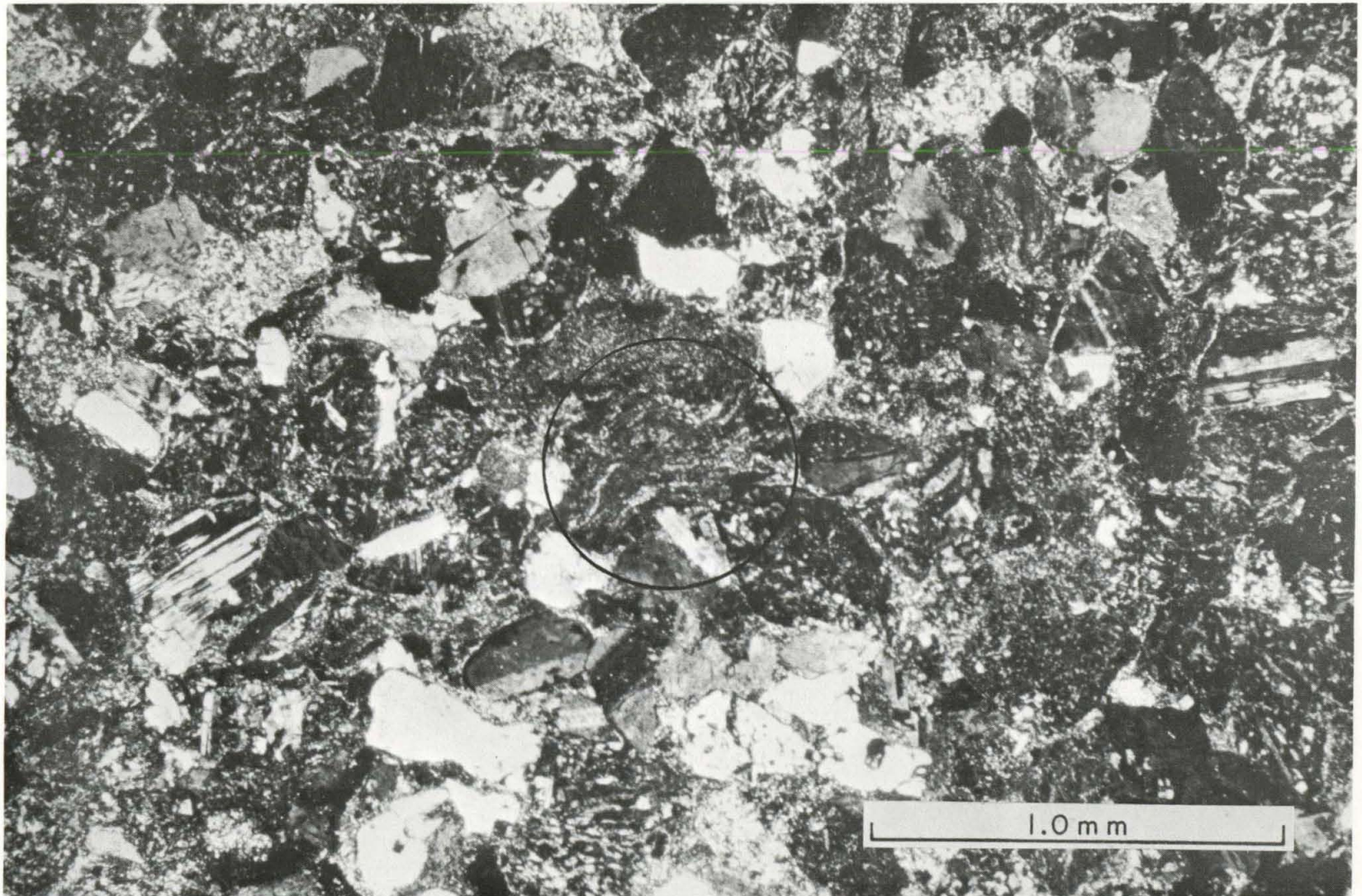


Figure 11. Volcanic arenite (I214), Buckley Formation. The fine-grained low-birefringent grains, in some cases with indistinct foliation (as in the circle), probably were once volcanic glass or pumice. Crossed nicols.

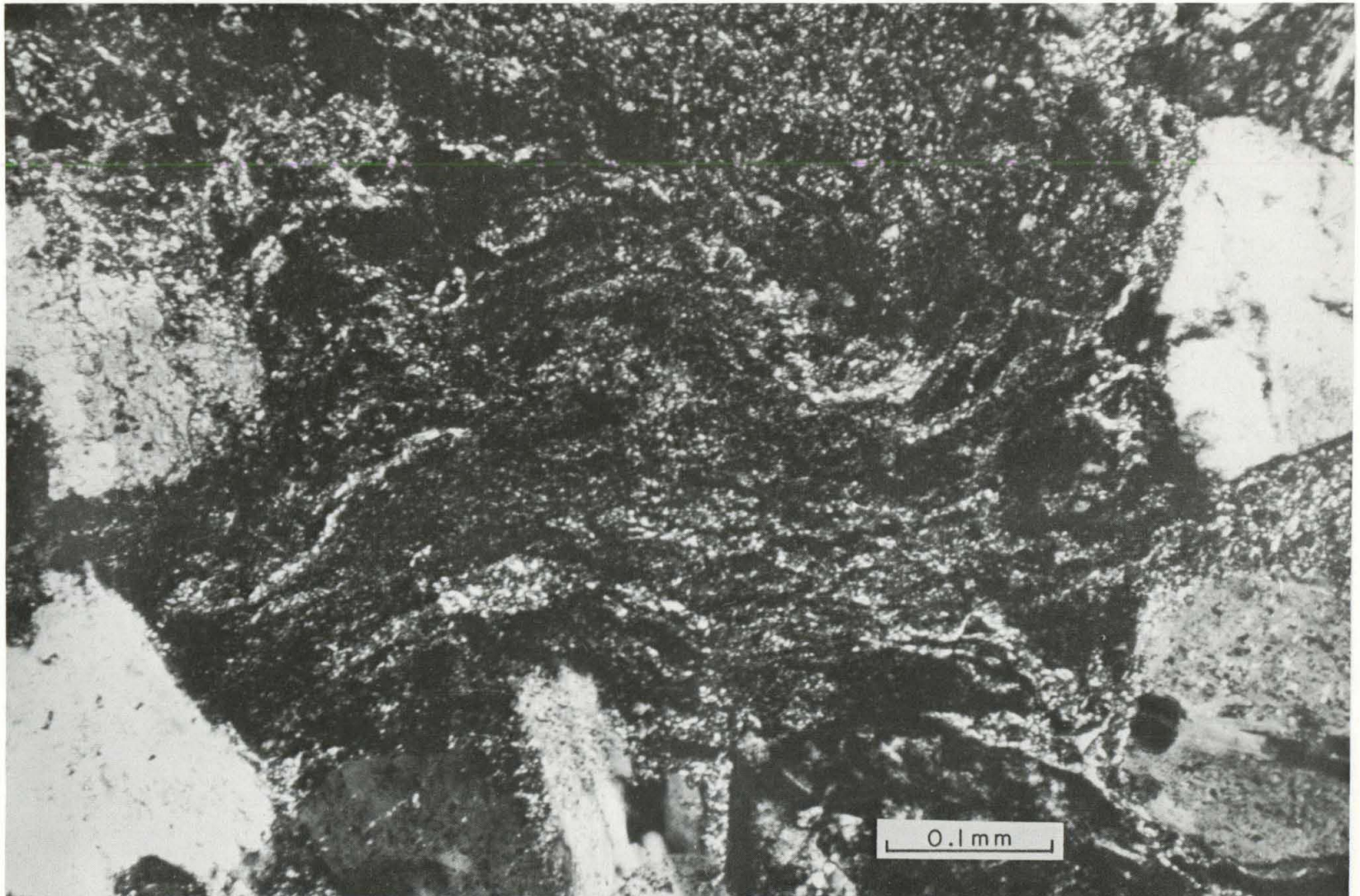


Figure 12. Volcanic arenite (L214), Buckley Formation. A closer view of the devitrified flow-banded volcanic fragment circled in Figure 11. Crossed nicols.



Figure 13. Volcanic arenite (L214), Buckley Formation. Pilotaxitic texture in two volcanic grains. Crossed nicols.

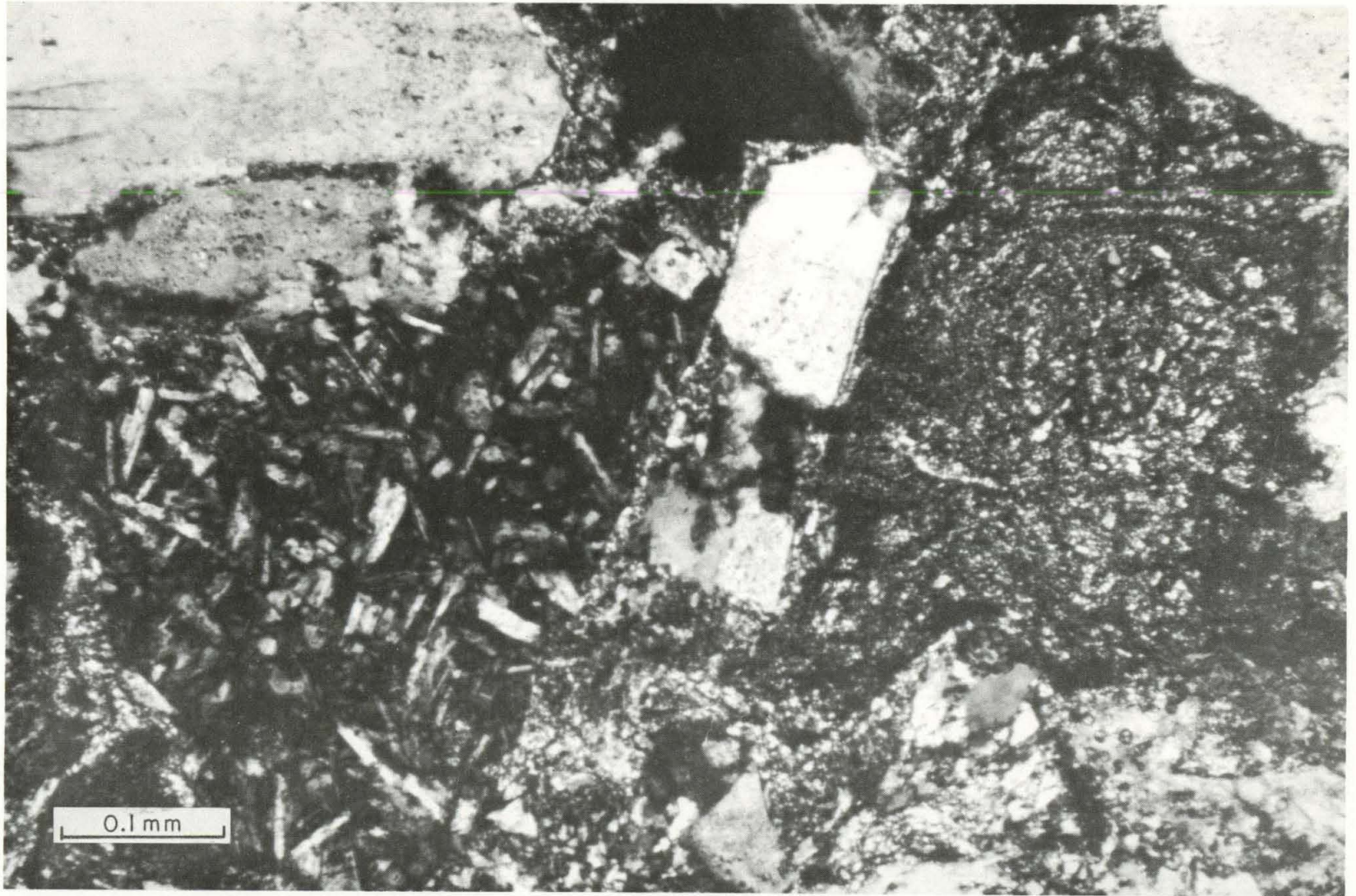


Figure 14. Volcanic arenite (L214), Buckley Formation. The grain on the left has hyalopilitic texture, with a semiopaque groundmass, presumably once glassy, between the plagioclase micro-lites. The dark fine-grained grain to the right has an indistinct foliation that, in this situation, suggests a volcanic origin. Crossed nicols.

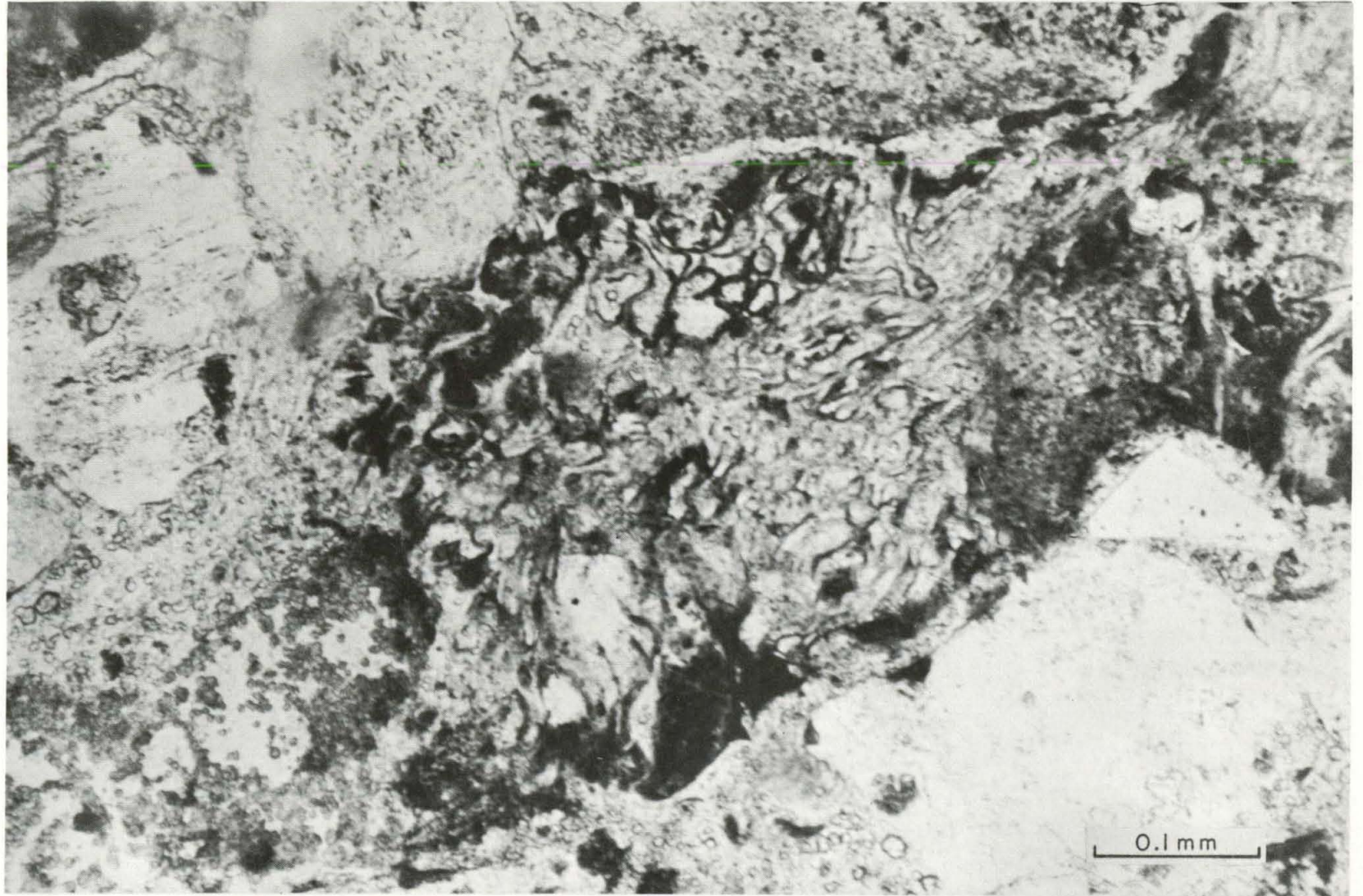


Figure 15. Volcanic arenite (L214), Buckley Formation. Fragments as obviously vesicular as the grain in the center are rare. The adjacent grains are lightly sericitized plagioclase. Plain light.

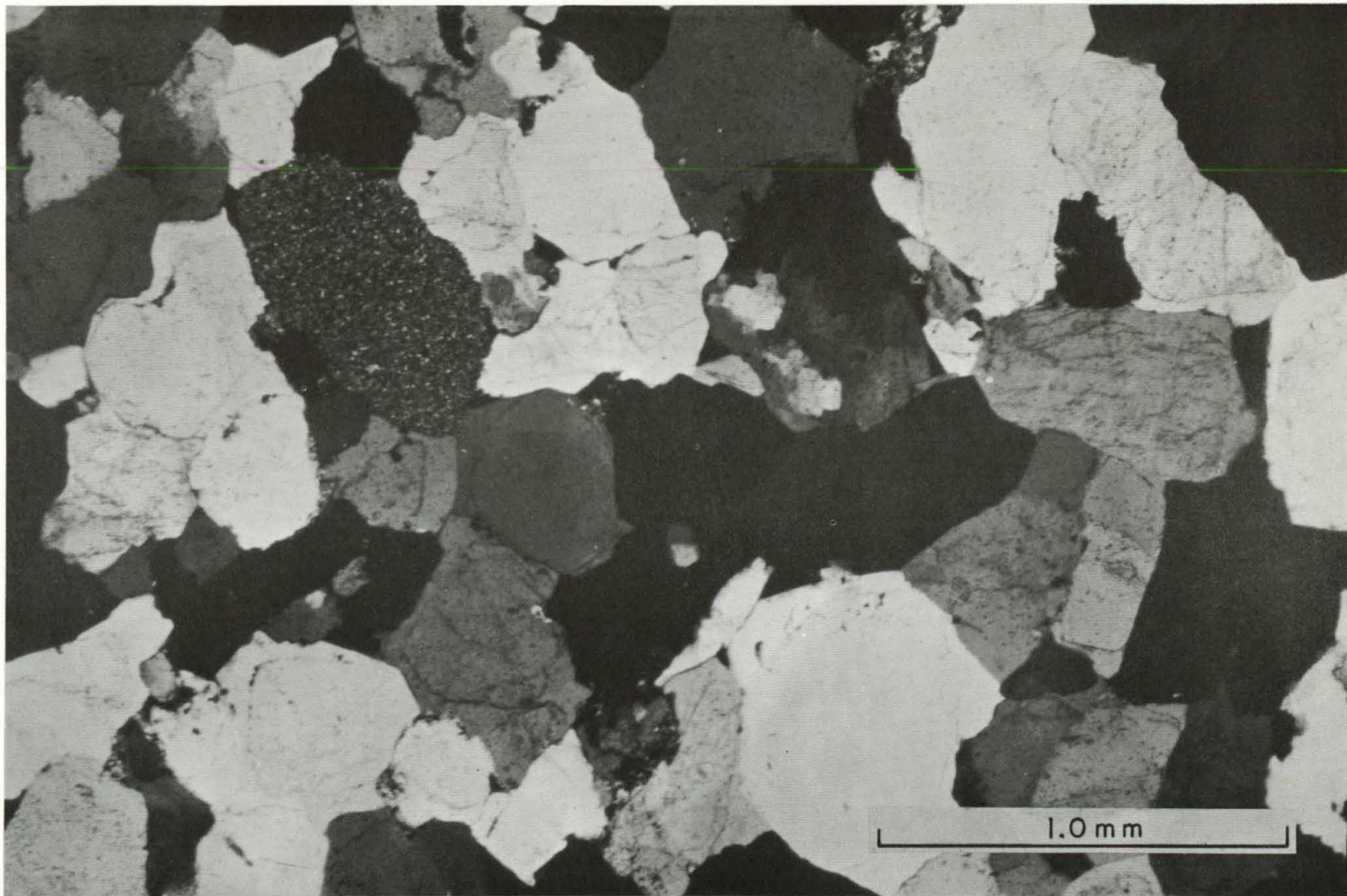


Figure 16. Quartz arenite (W117), lower part of Fremouw Formation. Subrounded to well-rounded quartz grains characterize this part of the Beacon sequence. Most grains have more or less straight extinction and are not composite. The cement is also quartz. The grain in the upper left corner of the photograph is chert. Crossed nicols.

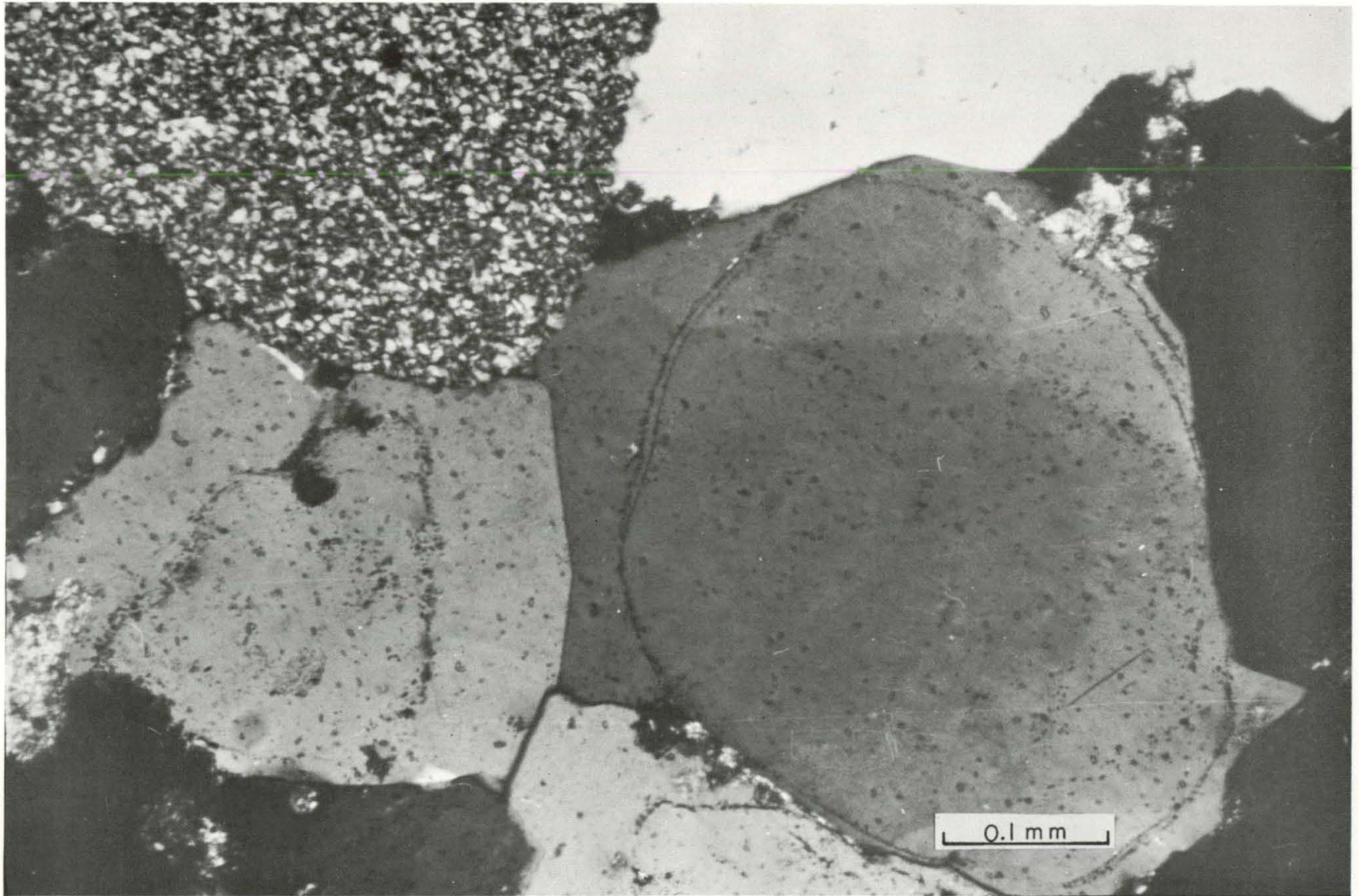


Figure 17. Quartz arenite (W117), lower part of Fremouw Formation. An enlargement of part of Figure 16. The limits of quartz overgrowth on each grain are defined by crystal faces (center). The double rim on the well-rounded quartz grain (right) shows that it has experienced at least two cycles of erosion. Crossed nicols.

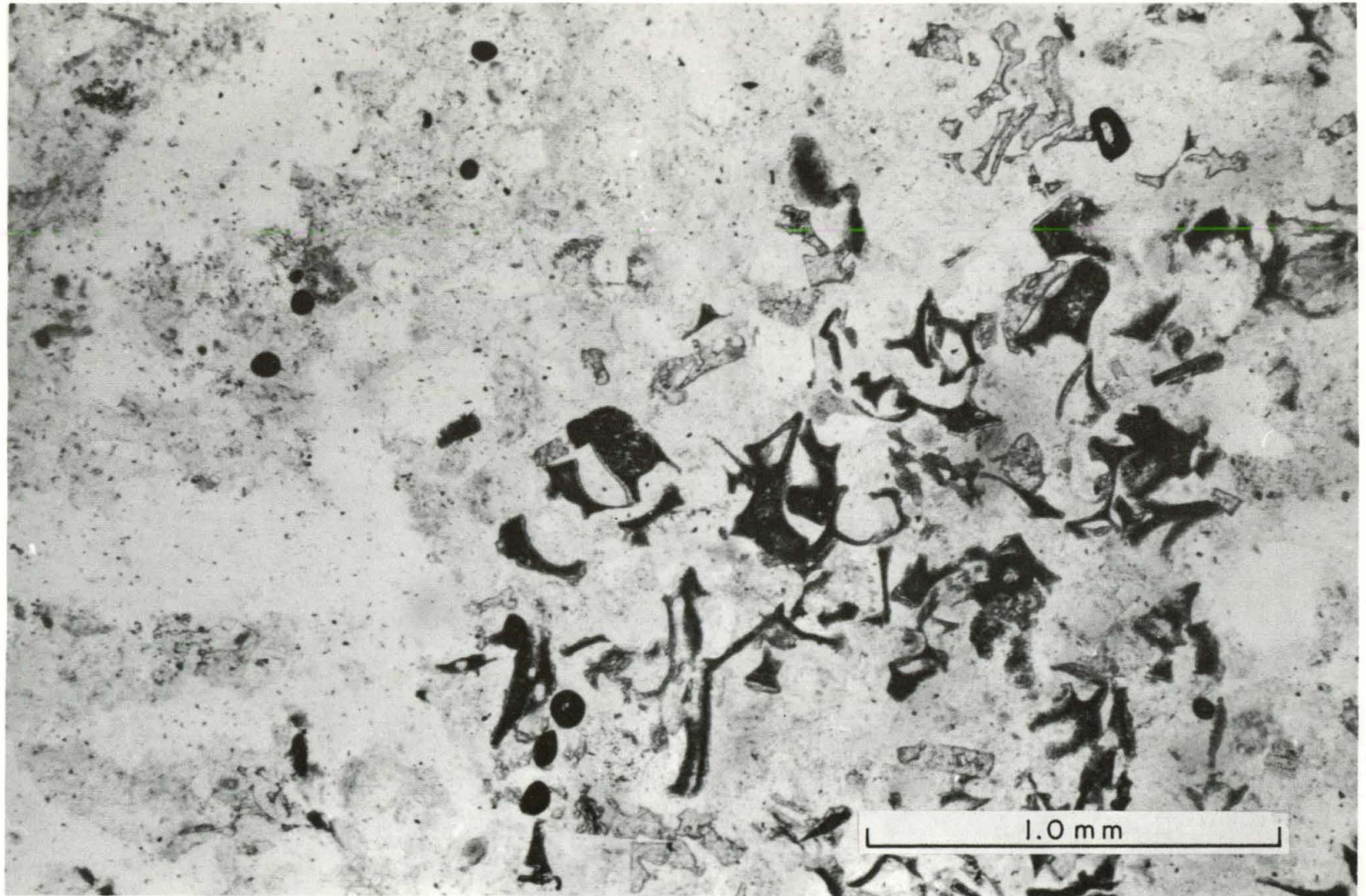


Figure 18. Vitric tuff (W130), middle part of Fremouw Formation. The sample has spheroidal areas as much as 1 cm across in which the glass shards have been replaced by calcite. The photograph is centered on the edge of such an area. Where there has been no replacement (upper left) the rock is fine grained, low birefringent, and shard forms are difficult or impossible to identify. In contrast, the shards are easy to recognize where they have been replaced by calcite (lower right). Plain light.

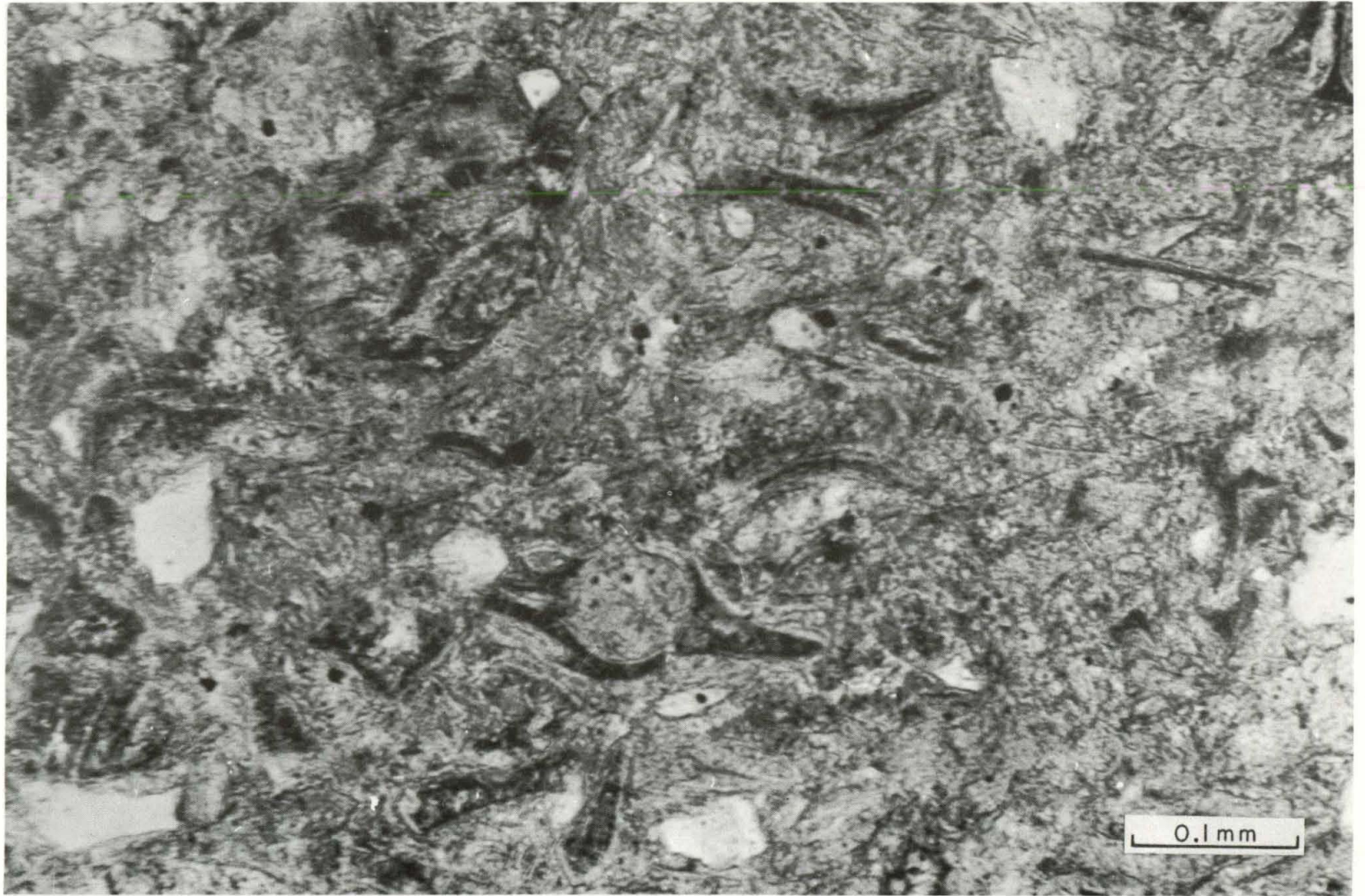


Figure 19. Vitric tuff (F239), upper part of Falla Formation. Quartz and feldspar fragments are scattered among the elongate glass shards. Analcime shows up strongly on the X-ray diffraction pattern, so it is assumed that the isotropy of the shards is due to this mineral, and not the presence of unaltered glass. Plain light.

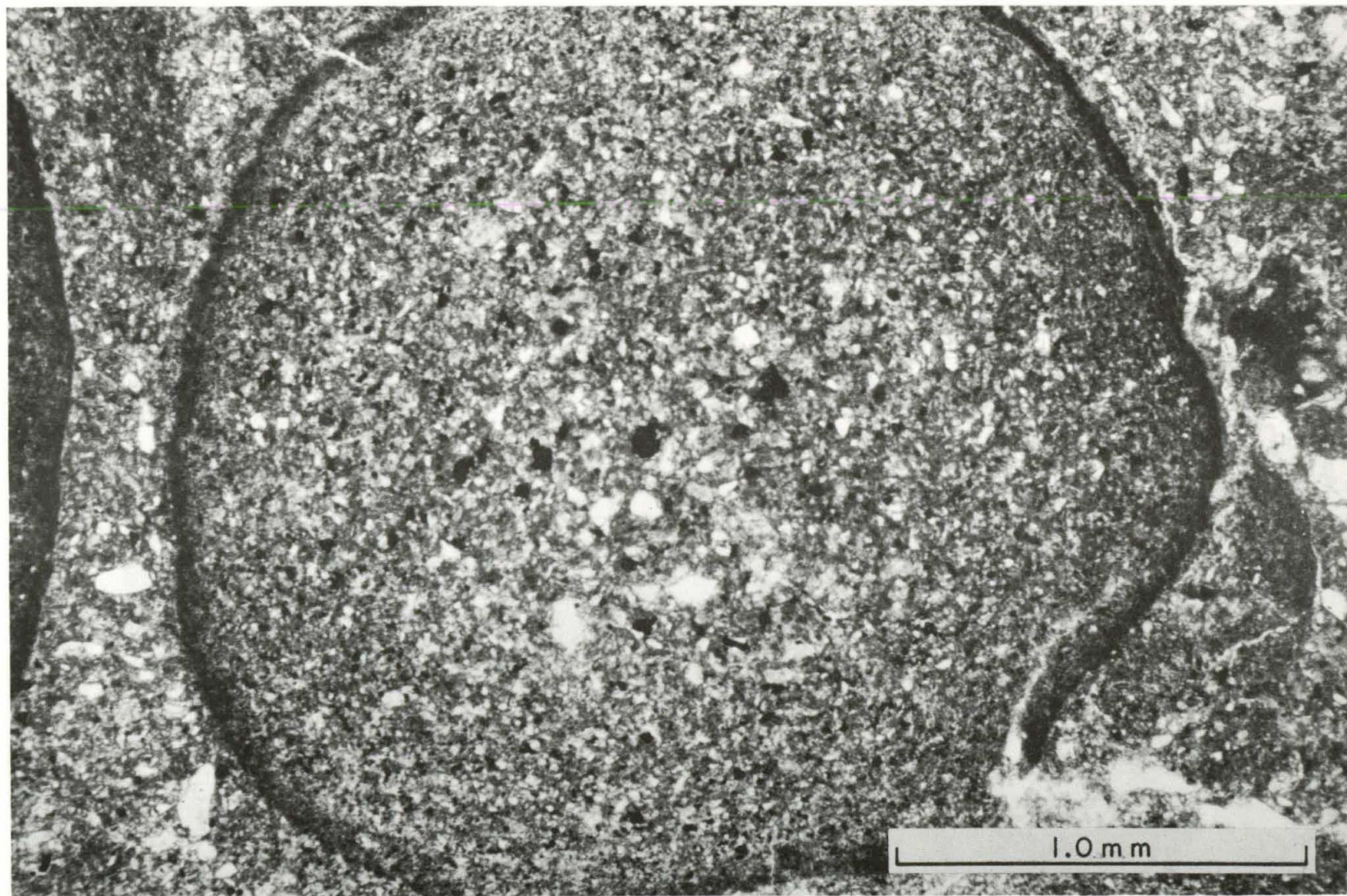


Figure 20. Accretionary lapillus, Falla or Prebble Formation, collected by Dr. D. H. Elliot (sample 39.6) from Elliot Peak, southern Queen Alexandra Range. The poorly-sorted core is surrounded by a finer-grained mantle which has a crude concentric foliation; the lapillus normally is surrounded by a rim of fine opaque dust as much as 0.1 mm thick, as is seen here. Plain light.

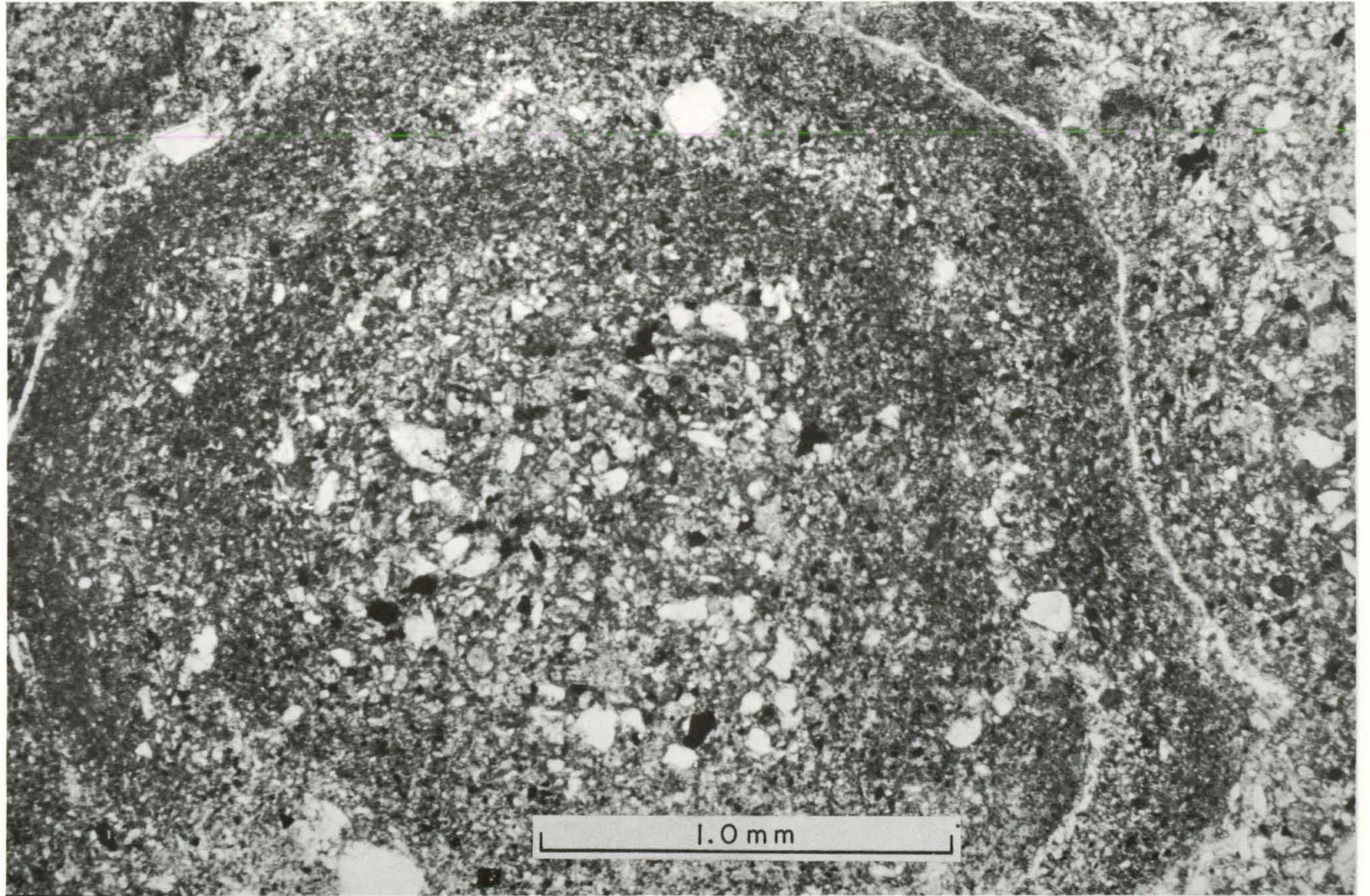


Figure 21. Accretionary lapillus, Falla or Prebble Formation, collected by Dr. D. H. Elliot (sample 39.6) from Elliot Peak. One lapillus has formed the nucleus for another. Plain light.

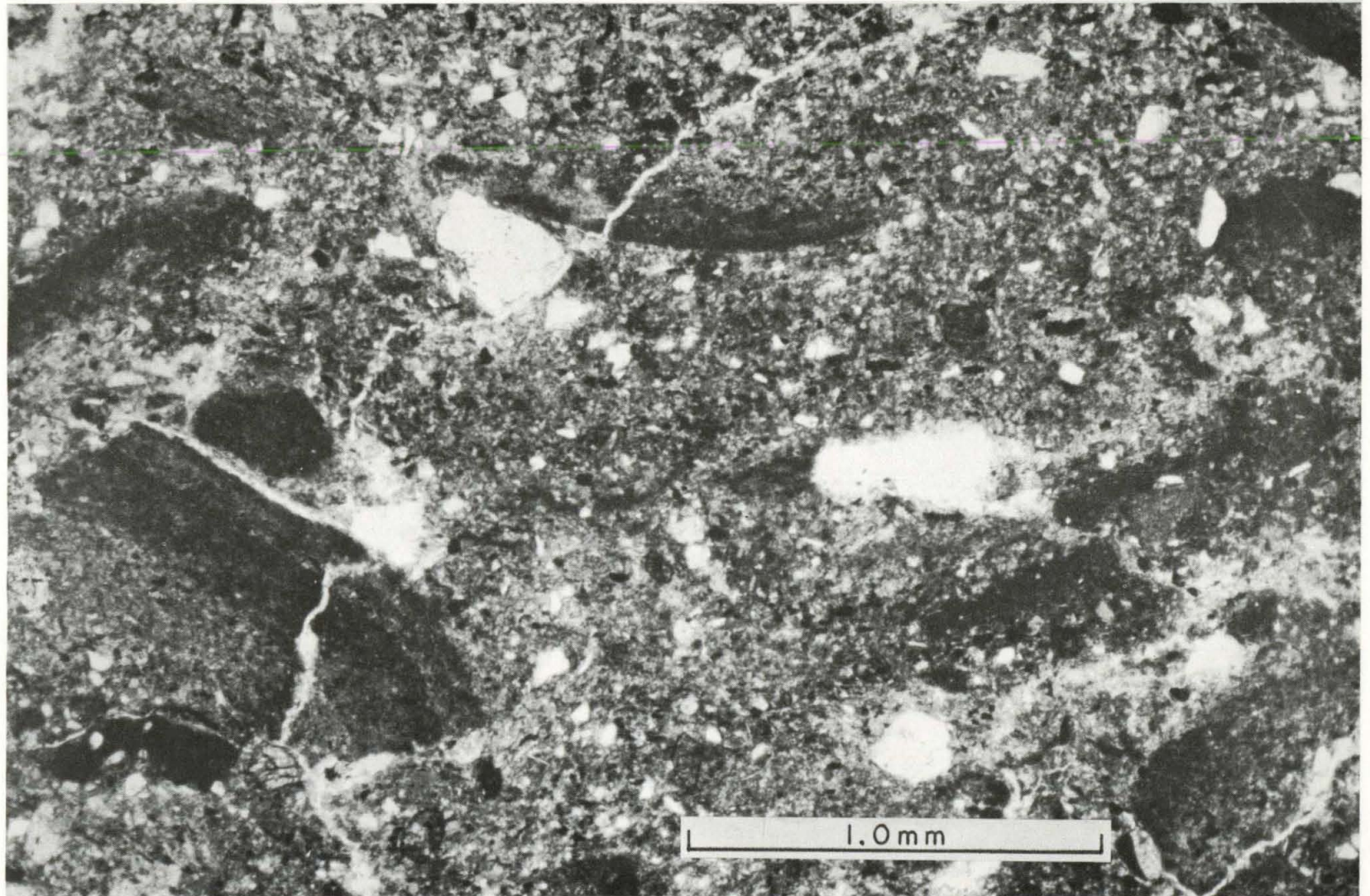


Figure 22. Lapilli tuff (F249A), Falla Formation. The fragments of the mantle and rim of accretionary lapilli were presumably broken on impact. Plain light.

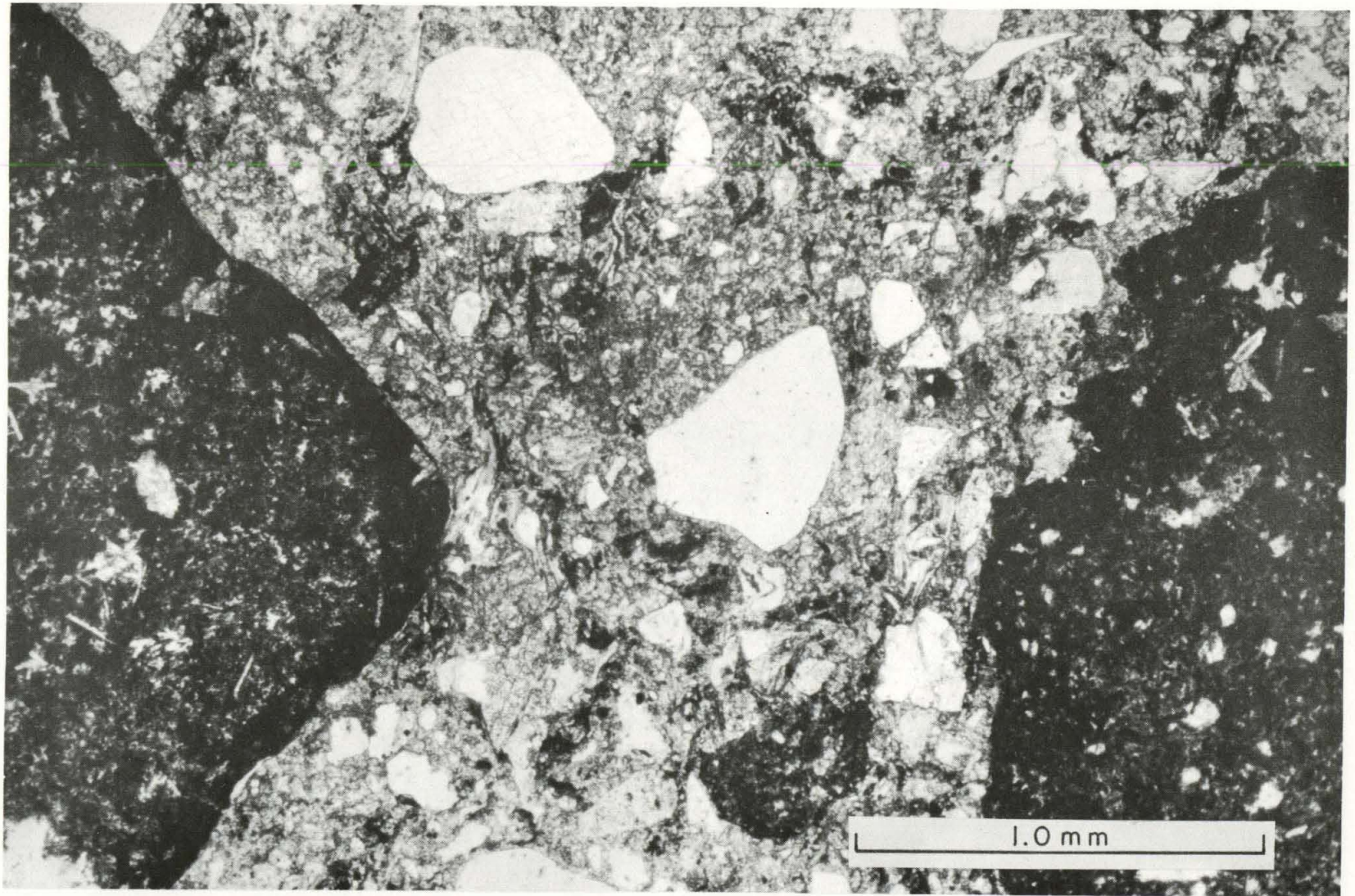


Figure 23. Paraconglomerate (F255), Prebble Formation. Feldspar (upper center, with cleavage) and quartz are scattered throughout the matrix, which here includes clinoptilolite. Analcime has replaced some of the clasts (not shown). Andesitic clasts form the left and right margins of photograph. Plain light.

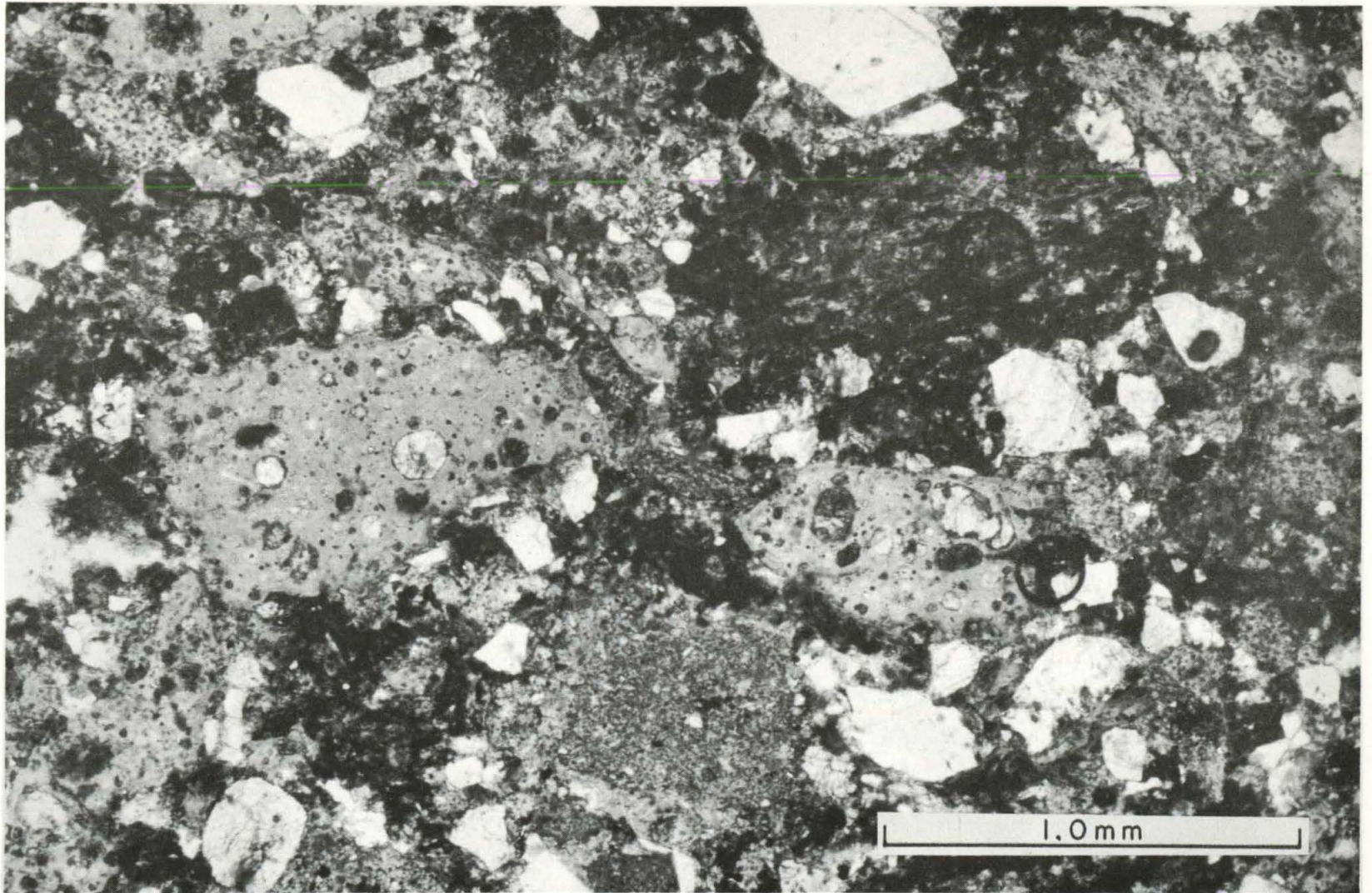


Figure 24. Paraconglomerate (T113), Prebble Formation. Most of this sample consists of partly devitrified glass fragments, many of which have vesicles filled with calcite (as in the light-colored fragment to the left), or chlorite. Plain light.